

ANNUAL PROGRESS REPORT FOR
**"SPACE RESEARCH, EDUCATION, AND RELATED ACTIVITIES
IN THE SPACE SCIENCES"**

Cooperative Agreement #NCC 5 - 356

For the period October 1, 2000 - September 30, 2001

Submitted To:

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From:

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Dr. David Black, PI



A handwritten signature in black ink, appearing to read "David V. Holdridge". The signature is written in a cursive, flowing style and is positioned above a horizontal line.

Mr. David Holdridge
Program Director

INTRODUCTION:

The Universities Space Research Association received an award of Cooperative Agreement #NCC 5 - 356 on September 29, 1998. The mission of this activity, known as the Cooperative Program in Space Sciences (CPSS), is to conduct space science research and leading-edge instrumentation and technology development, enable research by the space sciences communities, and to expedite the effective dissemination of space science research, technology, data, and information to the educational community and the general public.

To fulfill this mission, USRA recruits and maintains a staff of scientific researchers, operates a series of guest investigator facilities, organizes scientific meetings and workshops, and encourages various interactions with students and university faculty members.

ACCOMPLISHMENTS:

Scientific Research and Instrument Development:

As an indication of scientific research accomplishments, USRA scientists working under this Cooperative Agreement submitted 34 PI-level research and education proposals during the year. Indicative of the high level of community action, a majority of these submitted proposals were made in conjunction with a university-based collaborator. There was a good success rate. What follows are abstracts from independent scientific proposal awards received during the year to USRA staff Principal Investigators:

Corbet, R.; Astrophysics Data Program/RXTE; "Monitoring and Discovering X-ray Pulsars in the SMC (and the Galaxy) with RXTE."

Our continuing RXTR monitoring program of the SMC has been extremely successful. The results from RXTE and other satellites show that the SMC contains many more transient Be star X-ray pulsars than would be expected based on a scaling from the number of such sources in the Milky Way and the relative masses of the two galaxies. One speculation is that there has been a relatively recent burst of star formation in the SMC triggered by an interaction with the Milky Way. Highlights of our program include the discovery of new sources and the discovery of pulsations from SMC X-2. A major goal of our long running program is to determine orbital period of a number of these sources. This would then enable a comparison of the properties of the SMC and Milky Way X-ray pulsars and so provide information on star formation history in the two galaxies.

Corcoran, M.; Astrophysics Data Program; "The X-ray Lightcurve of Eta Carinae - Return from Apastron."

Since AO-1, we have been monitoring X-ray variations of the extremely

massive Eta Carinae with RXTE. These observations have uncovered new phenomena: 1) we proved the recurrence of the X-ray “low state” and detail the wild variability of the 2-10 keV emission prior to the start of this “low state”; 2) we discovered flares in the emission with $\dot{P} \sim 84$ days and non-negligible \dot{P} ; 3) we measured the change in N_H and kT through the low state and afterwards; 4) we constrained the time of periastron passage and found evidence of an increase in \dot{M} from the primary starting at periastron. It is crucial that we continue the RXTE monitoring in order to completely define the X-ray cycle, to determine the repeatability of the X-ray flux, and to determine whether Eta Car is in fact a binary.

Ebisawa, K.; Astrophysics Data Program; “GINGA, Final Calibration and Data Analysis.”

Although all the GINGA LAC data have been converted to the standard FITS format, thanks to previously funded projects, US astrophysicists may not analyze GINGA LAC data yet – because data analysis software and calibration information are not easily available. At ISAS, the established GINGA analysis system has been working on the mainframe machine. We propose to port the ISAS GINGA analysis system to Unix, modify the data I/O to read and write standard FITS files, so that people can continue the GINGA data analysis. The ISAS GINGA system includes precious databases, such as parameter-based background reproduction and night earth non-x-ray background, which would never be available to US astrophysicists unless serious reservation efforts are not made.

Drake, S.; Chandra Cycle 3; “A High-Resolution Study of the Active Binary System V824 Ara.”

We propose to observe the active G5+KO dwarf binary system V824 Ara (HD 155555), a very young (zero-age main-sequence or pre-main sequence) system with a 1.68 day orbital period, using the Chandra ACIS-S/HETG instrument. V824 Ara is a synchronized binary similar in age to the prototype young singly K dwarf AB Dor. We will study the X-ray spectrum, both integrated over the whole exposure and as a function of orbital/rotational phase and overall emission level. We will use these spectra to infer the coronal temperature structure or DEM, and elemental abundances. We will compare these coronal properties to those of evolved active binaries (e.g., AR Lac), and also to those of AB Dor and similar young stars, to see if there are discernible differences due to binarity and evolutionary stage.

Harrison, I.; Chandra Cycle 3; “The Mystery of Composite Supernova Remnants: The Case of MSH 11-62.”

Composite supernova remnants (SBRs) are the quintessential end-products of massive star collapse. As their name suggests, they embody the characteristics expected of typical SNRs, i.e. shell-like thermal X-ray emission associated with the explosion blast wave, as well as a compact

nonthermal component powered by a central neutron star. By their very nature, composite SNRs provide clues on both facets of SNR evolution: the shell-like part present in most standard SNRs and the synchrotron emission which has been, until recently, only detected in a handful of supernova remnants. One crucial aspect of the study of composite SNRs is the ability to separate spatially and spectrally these two components.

Nandra, K.; Chandra Cycle 3; "The X-Ray Universe at High Redshift."
Deep optical surveys show a population of star-forming galaxies at high z . These are probably in the process of formation, evolving into local ellipticals and spirals. X-ray observations can determine the influence of AGN activity on their evolution, and gives an independent measure of the star formation rate. We propose a 200 ks observation of the Groth-Westphal Survey area to determine the X-ray emission and AGN content of galaxies out to $z=3$. This is a very intensively studied region of the sky; notably for our purposes it contains over 200 spectroscopically confirmed Lyman Break Galaxies. It is targeted for numerous future deep surveys (e.g., SIRTIF, GALEX) and a huge spectroscopic survey by the DEEP consortium, offering enormous archival potential beyond our own exploitation of the data.

Mukai; RXTE; "Catching Intermediate Polars in Outburst."
Most magnetic cataclysmic variables of the intermediate polar (IP) subclass are believed to accrete via a partial accretion disk. Several IPs have been observed in outburst, a state of increased mass transfer from the disk onto the magnetic white dwarf. Some lines of evidence suggest that IP outburst may be mass transfer events from the secondary, unlike dwarf nova outbursts (in non-magnetic systems) that are caused by disk instability; however, this has not been proved beyond reasonable doubt. X-ray observations of IPs in outbursts can provide unique information about the IP outbursts, the accretion geometry of IPs, and possibly the outbursts of non-magnetic systems. We therefore propose TOO observations of all suitable IPs in outburst.

Smale, A.; RXTE; "LMC X-2: The First Extragalactic Z-Source?"
Data from a 100ks RXTE observation of LMC X-2 in 1997 Dec reveal that the shapes of the color-color and hardness-intensity diagrams, the presence of VLFN and HFN in the power spectra, and the high intrinsic L_x are more typical of a flaring Z-source than an atoll source (Smale and Kuulkers, 1999, ApJ, 528, 702). This would make LMC X-2 the 8th Z-source known, and the first detected beyond our Galaxy. We also found a strong 8.16-hr. modulation, which appears to confirm a candidate P_{orb} from optical photometry, though we cannot rule out a chance alignment of flares. One follow-up pointing is planned for Cycle 5; we propose further observations in 2001 to study the time variability of LMC X-2, flesh out its probable Z, and confirm/reject the 8-hr periodicity.

McGlynn, T.; AISRP; "Classifying the High Energy Universe: A Prototype of the National Virtual Observatory."

Under the direction of Dr. Thomas McGlynn, USRA and STScI (as a subcontractor to USRA) will prototype the National Virtual Observatory, building the tools and protocols needed to integrate large, distributed data sets to do science -- infeasible with a single institution's resources. The pilot research project is to build an automated classifier for X-ray sources, and to use it to try and distinguish the physical classes of all known X-ray objects.

Shrader, C.; FUSE Cycle 2; "Far-UV Spectroscopy of X-Ray Novae."

We propose to obtain Far-UV spectroscopic observations of X-Ray Nova events selected on the basis of their optical-UV brightness and absorption characteristics. A recent case, XTE J1118+480, represents an excellent candidate to achieve our goals if it remains (or becomes) active during FUSE Cycle-2. This program, if approved, will be executed in coordination with related ToO programs utilizing the RXTE and the HST. Specific goals for FUSE include simultaneous measurements of the ionizing X-ray flux and the strengths of O VI, CIII, and NIII lines. These measurements can then be applied as density, temperature, optical depth, and abundance diagnostics within the context of photoionization model calculations. In addition, we will search for variability on time scales of second, resulting, for example, from reprocessing of an X-ray flare in an accretion disk.

Papers Published:

The USRA scientific staff maintained a high level of scientific productivity during the year. As a natural follow on from the above mentioned research projects, the CPSS had a total of 141 papers accepted for publication in refereed scientific journals (counting only once papers with multiple CPSS staff co-authors). A summary of the publication citations is attached to this report.

Visitors & Consultants

CPSS experienced a continued high level of visitor and consultant activity during the period October 2000 through September 2001. There were a total of 63 visitors - mostly coming to visit GSFC. The average length of visitor stays was 9 days. Visitors may come for one-to two days to give a seminar, or to stay for a few months during the summer. Consultants, of which there were 11 over the reporting period, may be contracted over the full year, but may only work for 10-20 days out of the year.

Workshops & Meetings

CPSS organized, and/or participated in running the following meetings and workshops over the reporting period:

- 9/22-23/00 - GLAST Science Working Group - GSFC
- 10/5-6/00 - OWL-SWG meeting - GSFC
- 10/9-11/00 - RXTE Proposal Review - UMD
- 11/5-10/00 - HEAD meeting - Honolulu, HI
- 2/28/01 - ASTRO-E2 Site Visit - GSFC
- 2/22/01 - WAAM Meeting - GSFC
- 3/23/01 - HEASARC User's Group (HUG) meeting - GSFC
- 4/2-3/01 - GLAST Science Working Group - Baltimore, MD
- 4/3/01 - Compton 2001 Educator Workshop - Baltimore, MD.
- 4/3/01 - Advanced Compton Telescope Workshop - Baltimore, MD
- 4/4-6/01 - GAMMA Ray Astrophysics 2001 Conference - Baltimore, MD
- 5/16-17/01 - GLAST LAT Quarterly Review; GSFC
- 7/18/01 - Alan Bunner's Retirement Dinner & Celebration; GSFC
- 7/15/01 - GLAST ACD Review; GSFC
- 8/3-4/01 - SWIFT Educational Committee meeting; Sonoma State University, CA
- 9/10-12/01 - X-Ray Astronomy School; GSFC & Holiday Inn, Greenbelt

Space Science Education and Outreach:

USRA scientists again team-taught a course, Astronomy 191, at GWU in Washington DC in the Spring, 2001.

A LHEA group led by Dr. Jim Lochner have continued to conduct numerous workshops for education groups. A listing of these workshops follow. In addition, appended to this report, is a report from our subcontractor, SP Systems, describing their underlying activities within the Laboratory for High Energy Astrophysics in support of Dr. Lochner.

- 11/6/00 - "Imagine the Universe! Educator Resources" Science Teachers Assoc. of New York State annual conf.
- 11/9/00 - Educator Workshop at HEAD meeting, Honolulu, Hawaii.
- 11/16/00 - "Tour the X-Ray Sky" - NSTA Regional Meeting, Baltimore, MD.
- 12/1/00 - "Tour the X-Ray Sky" - Pennsylvania Science Teachers Assoc. Annual Meeting.
- 2/23/01 - Minority University Initiative Grant Winners, NASA/GSFC
- 3/3/01 - "Exploring the Universe with StarChild" - Alabama Aerospace Celebration (Alabama Education Assoc.).
- 3/7/01 - "The Great Beyond - Astro E2" - National Teachers Training Inst. - Harrisonburg, VA.
- 3/24/01 - "The Hidden Lives of Galaxies" - NSTA 2001 - St. Louis, MO.
- 4/3/01 - Compton 2001 Educator Workshop - Baltimore, MD.

- 4/26/01 - Take Our Daughters to Work Day - GSFC
- 5/15/01 - ASPIRA - Latino Educator Conference; Atlantic City, NJ
- 6/14/01 - Undergraduate College Workshop, NASA/GSFC
- 7/10/01 - NASA Education Workshop (NEW) Urban Workshop, NASA/GSFC
- 7/12/01 - National Youth Science Camp, WV
- 7/13/01 - N. J. Educators, NASA/GSFC
- 7/17/01 - Visit by National Youth Science Camp to GSFC
- 7/18/01 - Anne Arundel County Earth System Science Teacher Academy, NASA/GSFC
- 7/19/01 - "Teacher Thursdays" Program, Maryland Science Center, Baltimore, MD
- 7/25/01 - NASA Educator Workshop, NASA/GSFC

Student Activities

The CPSS Student Research Opportunities program placed three students this year with LHEA and CPSS researchers who mentored them for approximately 10 weeks as they participated in various research projects at GSFC.

PROGRESS RELATED TO GOALS:

No explicit program-wide goals were established relative to the activities undertaken within the CPSS. However, from a staffing and financial standpoint, everything appears nominal. As of September 30, 2001, 36 months (and 86%) into the 42 month cooperative agreement, USRA had expended \$15.6 million or 81% of the Co-op Agreement total value. At the end of the reporting period, USRA employed a total of 35 scientific staff.

PROBLEMS EXPERIENCED:

None



**COOPERATIVE PROGRAM IN SPACE
SCIENCE**

(CPSS)

**NASA COOPERATIVE AGREEMENT
NCC 5 – 356**

Publications Listing

1 October 2000 through 30 September 2001

**UNIVERSITIES SPACE RESEARCH ASSOCIATION
(USRA)**

**David V. Holdridge
Program Director**

USRA CPSS 2000 - 2001 Scientific Publications List

1. Adams, Mike; et al. (incl. **Lienard, Sebastien**); April 2000: "Design and Flight Testing of an Inflatable Sunshield for the Next Generation Space Telescope (NGST);" AIAA-2000-1797.
2. Almy, R. C., (Univ. Wisconsin); McCammon, D., (Univ. Wisconsin); **Digel, S. W.**, (USRA); Bronfman, L., (Univ. Chile); and May, J., (Univ. Chile): "Distance Limits on the Bright X-ray Emission Toward the Galactic Center: Evidence for a Very Hot ISM in the Galactic X-ray Bulge", *Astrophysical Journal*, 545, 290.
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8. Bloser, P. F.; Grindlay, J. E.; Kaaret, P.; Zhang, W., and **Smale, A. P.**; 2000: "RXTE studies of long-term X-ray spectral variations in 4U1820-30," *ApJ*, 542, 1000.

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10. **Bonnell, J. T.**, (NASA/USRA), Nemiroff, R. J., (Mich. Tech. Univ.); 2000: "Astronomy Picture of the Day in the Classroom;" American Astronomical Society Meeting 197, 54.04.
11. **Bonnell, J. T.**, (NASA/USRA); Norris, J. P., (NASA/GSFC); 2000: "Energy Dependent Timescales In Long Gamma Ray Bursts", American Astronomical Society, HEAD meeting 32, 34.0.
12. Boroson, B. (GSFC); Kallman, T. (GSFC); Vrtilek, S. (CfA); Raymond, J. (CfA); **Still, M.** (USRA/GSFC); Bautista, M. (GSFC); Quaintrell, H. (OU); 2000: "Hercules X-1: Empirical Models of UB Emission Lines;" *ApJ*, 529, 414.
13. Boroson, B. (GSFC); O'Brien, K. (Amsterdam); Horne, K. (St. Andrews); Kallman, T. (GSFC); **Still, M.** (USRA/GSFC); Boyd, P. (UMBC); Quaintrell, H. (OU); Vrtilek, S. (CfA); 2001: "Discovery of Millihertz Ultraviolet Quasi-periodic Oscillations in Hercules X-1;" *ApJ*, 545, 399.
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SP Systems: Annual Report – 2000-2001

Educational Public Outreach

Customer: NASA/Goddard Space Flight Center (GSFC), under subcontract to University Space Research Association.

Project Description:

i. Educational tools

SPS members maintained many large educational web sites, worked with educators to develop instructional materials such as lesson plans and activities for students, create educational CD-ROMs, posters, activity booklets and other materials meant to inspire and teach students. SPS member have also helped create Web-based "learning centers" to educate the general public about specific Laboratory for High Energy Astrophysics (LHEA) missions. We have designed a series of posters for grades K-12 each highlighting some aspect of LHEA science and featuring an activity book for the classroom which teachers can use to plan lessons. SPS members periodically visit classrooms to demonstrate scientific principles, act as teacher liaisons, mentor students, and volunteer in the community at astronomy clubs and Goddard community days. SPS members regularly attended the national and regional Science Teacher Association meetings to distribute materials, demonstrated products, and give workshops to teachers on how to include scientific data in their classroom lessons. SPS members were also responsible for distributing educational products to those who request them nationally and internationally, and they contribute to the "Ask-A-NASA-Scientist" service by answering astronomy questions submitted by the public.

SPS member prepared a series of educational CDs that contain several complete Web sites ("Imagine the Universe", "Starchild", etc.). They are distributed especially to facilities that may lack internet access or have connections that are too slow to allow satisfactory viewing of larger image and video files. We have assisted in the preparation of several short videos to illustrate and explain the missions. These videos are distributed on CDs and are made available for viewing through the Web sites by way of streaming video, such as Real Video. SPS members provide educational materials for such key NASA missions as the Chandra X-ray Observatory, the Rossi X-ray Timing Explorer and the Compton Gamma Ray Observatory. Upcoming missions that SP Systems will support include Swift, the Gamma Ray Large Area Telescope, the Constellation X-ray Observatory, and the Microwave Anisotropy Probe.

ii. Media outreach

SPS staff science writer's support to media outreach activities included writing of press releases, fact sheets and web pages targeted for both print and broadcast media and the internet. SPS also provided support at scientific meetings (in the

press room), served as a host for visits by journalists to the Lab, and maintained a working relationship with individual members of the media. SPS member worked with the LHEA scientists from time to time to prepare graphics to accompany press releases placed on the Web.

iii. Digitized videos & VHS tape production

SPS has digitized videos from VHS tapes and created our own videos and animations using applications such as Digital Video Producer, GIF Animator, and QuickTime. We also maintained a Real Video server and have converted numerous digital videos (AVI and QuickTime) to streaming media to be served through the Web.

iv. Brochure and poster preparation

SPS members created brochures aimed at various audiences ranging from the general public to a specific group of high-energy astrophysicists. SPS members have written, collected or created photos and artwork, and done the layout, proofing, and pre-press for large-run brochures. SPS members created several full-color booklets and brochures for the LHEA using desktop layout software such as Corel Ventura, Adobe PageMaker, Adobe Framemaker, and QuarkExpress. In these efforts, we have designed the layouts, written and/or edited text, and selected images and illustrations to be included in the various publications. In some cases, illustrations for the booklets were prepared by direction of GSFC scientists to accompany their text contribution to the documents. Software packages such as Corel Draw, Photo-Paint, and Adobe Illustrator and Photoshop have been used to create illustrations and otherwise prepare images for inclusion in the booklets and brochures. We have also worked with print specialists to submit our documents for printing approval in compliance of NASA and Government Printing Office procedures, and to prepare electronic files for professional printing.

v. Technology and educational display support

SPS members attended scientific, technical, and educational meetings in support of the LHEA and its missions. Our professionally prepared display booths are set up and staffed during meeting hours. Display items commonly include samples of current technology and technology under development, such as X-ray mirrors, gratings, and micro-calorimeters. Handouts include booklets, posters, and CDs.

vi. Showcases / Displays

We have worked with professional booth vendors to select proper equipment and to design our displays. SPS member have designed elaborate displays and created artwork for backdrops, placard displays and banners for all types of booths ranging from the 8-foot arched pop-up display to a 12-panel display with

counters, computer monitors and brochure racks. These display booths, along with supporting materials and handouts, travel to the scientific and educational conferences and meetings.

vii. Web development

SPS members have developed and are responsible for several very large (100+ page) web sites and keep them up-to-date with the latest news, information, and site navigation technology. SPS member have been instrumental in the creation and maintenance of two Award-winning Web sites: "Imagine the Universe" a space science site for the general public (ages 14 and up), which receives 316,000 accesses per month; and "Starchild" a site for "young astronomers" (grades K-8), which receives 876,000 accesses a month.

SPS maintains and administers several Web sites for the LHEA. The sites reside on a Unix workstation, and we manage and administer this system, as well as the Web sites themselves. Maintenance includes editing NASA press releases for inclusion in the news section of the site, programming interactive activities in Perl, C, Java, and programming scripts, etc. The Web sites have been designed using various software packages such as Homesite (HTML editor), Flash, Fireworks, LiveImage, and Dreamweaver as well as plain text. Javascript and Perl are used to add functionality, such as Web-based forms, and flair, such as the dynamic HTML button rollovers and expandable menus.

viii. Application programming

SPS staff supported applications software development to provide tools such as web interfaces, DBMS applications, etc. SPS staff have multi-disciplinary background in science and programming. SPS staff followed a structured approach in understanding the requirements, developing a preliminary and detailed design prior to coding and a systematic testing plan at each stage of development. For reliable maintenance and reusability, a configuration control process was applied to all application software developed.

ix. Database support

SPS members are responsible for the creation and daily maintenance of scientific databases for the High-Energy Astrophysics Science Archive Research Center (HEASARC), a dedicated support facility for 12 NASA-supported missions, and the development of internet tools for astronomers using HEASARC to access/query the databases.

SPS members have created and maintained scientific databases using Fortran-based in-house database software as well as commercial DBMS software. Fortran and C programs were developed to populate/query data tables, which are made

available through the HEASARC online service. Astronomical catalogs were ingested; other tables included links to downloadable data files and images.